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ON PROJECT BASED LEARNING IN TRADITIONAL ENGINEERING STUDIES

Summary

The paper reviews experience from the implementation of a project based design-build (DB) course given during the last year of the master level education at two specializations at the Royal Institute of Technology (KTH). Key features concerning constructive alignment, efficient learning modes, the teacher's role, assessment and general implementation aspects are discussed. Traditional learning approach in mechanical engineering and naval architecture studies at University of Split are described and compared with methodologies developed at the KTH. Possibilities for implementation of project based learning and CDIO approach at University of Split are presented.

Key words: *engineering education, project based learning, CDIO*

O PROJEKTNO ORIJENTIRANOM UČENJU NA TRADICIONALNIM INŽENJERSKIM STUDIJIMA

Sažetak

Rad prikazuje iskustvo u implementaciji projektno orijentiranog kolegija koji se izvodi na zadnjoj godini dva smjera diplomskih studija na Royal Institute of Technology (KTH). Razmotrene su glavne značajke koje se tiču konstruktivne orijentacije, efikasnih načina učenja, uloge nastavnika, ocjenenjivanja te aspekti opće implementacije. Opisan je tradicionalni pristup učenja na studijima strojarstva i brodogradnje na Sveučilištu u Splitu i prikazana je usporedba sa metodama razvijenima na KTH. Prikazane su mogućnosti implementacije projektno orijentiranog učenja i CDIO pristupa na Sveučilištu u Splitu.

Ključne riječi: *inženjerska edukacija, projektno orijentirano učenje, CDIO*

1. Introduction

All engineering studies including studies of Naval Architecture at University of Split have been organized according to the Bologna principles for a few years. The first generation of 'Bologna students' has just finished studies. In parallel with the introduction of the Bologna system all the faculties at the university are undergoing through application of new teaching methodologies. These are supported by introduction of modern computer technologies that mostly include different kinds of local and remote Internet-based learning systems. The Bologna system and application of modern technologies should have been an upgrade to the traditional education system, hoping to reduce dropout of students on engineering studies, particularly on naval architecture and mechanical engineering studies. However, the statistics at Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture (FESB) in Split, after implementation of the Bologna system, show that the number of graduated students is still very low: for mechanical engineering and naval architecture studies that is less than 10%. This is a tremendous waste of financial and life resources. Analyses showed that students tend to tribute their drop-out to factors relating to study programmes and teaching methods, rather than to personal factors. Thus, engineering education gets a reputation to be 'too hard' or 'boring'. Along with the perceived risk of failure, this may deter future students from engineering education.

Study programmes at FESB are still those that cover general engineering topics with a lot of theoretical background. The greatest change in study programmes since the introduction of the Bologna system was a possibility to introduce a (unlimited) number of elective courses. Although the sheer number of elective courses is now quite large the study programmes allow for only 2 or 3 elective courses due to low number of students on higher study years. Another problem with elective courses is that in most cases topics have already been covered in mandatory courses. The development of more flexible programmes with less mandatory and more elective courses is now undergoing at FESB. The new programmes will cover knowledge and competences as described by Accreditation Agency for Degree Programmes in Engineering (ASIIN) [1] and European Society for Engineering Education (SEFI) [2].

Regarding teaching and learning methods nothing, or very little, has been done to replace or at least to improve traditional approach at naval architecture and mechanical engineering studies in Croatia. Most of the positive things regarding computerization are well known: access to information (journals, books, and software), fast communication, remote-learning, etc. The introduction of computers, specialized software, Internet and e-learning systems have only changed the way the teaching is done, but teachers' perception on education has not changed, i.e. PowerPoint presentations just replaced chalk and blackboard. The students are not attracted by the courses and they consider teaching methods not appropriate for engineering education. This discourages students and they give up their studies. They consider that if they work in the industry they will gain necessary knowledge through experience. The implementation of the Bologna system and computerization has only formally changed education system, but students' frustration with the programs attended has remained. It is, thus, of the greatest importance to introduce learning methods that will, in addition to providing technical fundamentals, inspire and encourage students to take an active role in their education as well as to prepare them students for professional roles in the development of systems and products.

There are many reported researches and experiences of implementation of non-traditional learning methods in engineering education such as active learning [3] and problem-based learning [4, 5].

The basics of those methods as well as of creative processes and some methods for provoking and stimulating creativity such as brain storming, brain writing 6-3-5 methods, lateral thinking, TRIZ, methods like the Walt Disney creativity strategy, design for six sigma, synectics and ideation in general are well summarized in [6].

Learning activities in project-based environments are being increasingly used in education at the university level for various reasons. In the engineering education the project-based learning has a natural place since the student when graduated likely will work in projects from day one in industry. Among the most appealing advantages is that of learning and practicing of some of the skills that traditionally are given subordinate attention in traditional higher engineering education, e.g. communication, creative thinking, team work, technical reasoning and modeling. Biggs [7] stresses the importance and advantages of active learning which according to the authors can be focused in project based activities.

Around 1990, a group of university engineering educators challenged aspects of the current approach of engineering education. The work has developed and resulted in a new approach to engineering education which can be summarized as Graduating engineers should be able to Conceive, Design, Implement and Operate complex value-added engineering systems in a modern, team-based environment. This approach has become known as CDIO. A detailed educational CDIO syllabus has been developed [8]. The CDIO program envisions an education that stresses the fundamentals, set in the context of Conceiving, Designing, Implementing, Operating systems and products.

Experiences on many universities, for example Royal Institute of Technology in Stockholm (KTH), show great benefits of teamwork projects, based on CDIO methodology, for both students and teachers.

It is intention here to summarize experience in project based engineering education from Department of Aeronautical and Vehicle Engineering at KTH and to give some recommendations on how to adapt their methods to FESB capabilities.

2. Experience with project based learning at KTH

This chapter summarizes experiences from a two-semester CDIO-based design-build course (DB-course) that runs at quarter speed during the last year of the master program specializations for lightweight structures and naval systems at KTH. The course typically contains 20-40 students whom are divided into project groups of 5-15 students mixed from the two specializations. Among the course objectives are to learn and practice to analyze technical problems from a systems perspective, to practically realize technical ideas, to reflect on, challenge and evaluate both achievements and solutions and to systematically optimize the utilization of various available engineering tools. The projects have basically two main phases, the first semester of conceiving and designing and the second semester of implementing, building, testing and operating. The second semester naturally is the more challenging where all solutions and analyses are put to test. The leap of actually realizing the product in contrast to ending the project after the design phase is very important since it rules out “cheating” with impractical solutions. The constraints given by the fact that the group are to realize the product sets critical judgments of uncertainties and other consequence analyses in focus. The authentic project setting with large groups, budgets, open-ended tasks etc puts quite a number of engineering skills in focus in a natural way. It is herein the core of the course lies – in becoming familiar with and practicing the true engineering skills integrated with the traditional topic-oriented knowledge acquired from other courses. The course has been given for some 10 years. Further aspects on the course design objectives are given in [9].

2.1. The importance of a good start

As always the start of a project is important to set the standards etc. It is usually no problem getting the group of students to be active and constructive at early stages. The challenge though is to lead the efforts in constructive directions that are of lasting use to the project in the long run. In several cases it has been experienced that eager students who too early have been allowed to pursue his/hers unchallenged initiative later get disappointed and discouraged when the endeavor did not bear fruit. Also, in the present course there is a great portion of actual hands on building involved. Students are typically not impressed and encouraged by the teacher who instead wants to focus on e.g. project management and assessment techniques.

To our experience, it is for these and other reasons important to carefully consider and plan the initial phase of the course. Quite some time can easily be spent on discussions on topics that from the eager students perspective is mostly disturbing and distracting. Various tactics have been tried to avoid this to happen where the most successful has been to alternate lectures with pure technical project meetings. Thus, student enthusiasm for the task is supported and the project starts before e.g. all course background is given.

In the early phases of the project students often feel that the specialist knowledge, often technical, is too limited. Hesitation and sometimes fear for tasks that are not solved by the use of knowledge taught in an earlier course at the university is not unusual. Sometimes such feelings lead to the positive situation where interlinking of other courses comes natural but other examples show that such topics are sometimes treated superficially and thus become the weak links of the project. Regardless of how such tasks are treated by the project and the individuals, they often become pedagogically interesting for e.g. reflecting during teacher led group discussions.

2.2. The learning modes

Teaching in a true DB-course has very little in common with teaching a conventional linear course. Early in the course the students (and sometimes also the teachers) are still stuck in their traditional roles. It has been found that since a good portion of the engagement in the beginning is concerned with administrative matters and getting the project started some practical teacher support is needed. Experience with too much student responsibilities too early in the project show that lack of experience and knowledge slows progress considerably with frustration and the risk of some indifferent students attitudes as consequence. Thus it is on the teacher to, sometimes by example; show e.g. how to efficiently chair meetings and reach well-supported decisions.

The DB-course allows for many various and quite different interactive learning modes ranging from seminars, lectures, meetings, workshops through one-on-one technical discussions to individual coaching. In situations where new energy needs to be injected into the project or at critical stages such as in preparation before a design review the workshop has proven to be extremely useful. A workshop leader, student or teacher, is appointed in advance with the main task to prepare and lead the group to solve problems during the workshop. The reached decisions are typically results of brainstorming type of activities or by rough paper and pen estimates usually done in smaller groups in 20 minutes and then reported before the entire project. The effects of such workshops are often amazing, both in terms of technical achievements and in terms of acting as project lubricant and energy booster. Some special workshop rules can be introduced if necessary. One rule that might be of value is the prohibition of the phrase and answer “I don’t know” to entice constructive estimates instead of new question marks.

Another effective teaching/learning situation is when the little sub-group, or single student, who has taken on a certain task to solve in a given time meet the teacher for guidance. Nothing unconventional so far, but the very large difference from problem solving in traditional courses is that the advising teacher, which typically is appointed when the task is defined, has a completely new role. Since the task is to be solved for the good of the project and thus the customer of the work is the project, the teacher and the student is now on the same side of the task definition with the common goal to solve the problem. This actually differs a lot from the usual situation in traditional courses where the teacher is typically defining the requirements for the task and also the one judging the results. Now, the student can, in an atmosphere of fellowship seek the teacher for guidance and the teacher without the fear of giving one student an unjust advantage can give this guidance.

A challenging part of counseling of students in various topics is that quite often the tasks to be solved include considerable use of technologies which are not within the field of expertise of the teacher. This might at first be discouraging but actually means that the teacher in a realistic way can advise the students on techniques to solve problems without the usual situation of the teacher having pre-knowledge of the solution. The concurrent explorations however expose the teachers' limitations, which might feel somewhat unusual and uncomfortable at first. The students on the other hand might now actually find himself/herself in the unusual and inspiring situation to actually have equal or deeper specialist knowledge than the teacher. Especially situations where the students become the specialists help bringing in change in the traditional student-teacher relation. As the project progresses the teacher' role changes very clearly. From being the supervisor the role of the teacher gradually and continuously shift toward the role of an advisor or coach in the everyday work within the project.

2.3. Course implementation

Some important decisions are naturally made before the actual course starts. Among the more interesting decisions are whether or not an external costumer from the industry should be involved. There are several advantages with an external costumer such as that the project have a chance to be economically sponsored, that students might strive some extra, that the need for good communication is authentic etc. However, the teachers at KTH are convinced that the gain of using external costumers is sometimes exaggerated. It is in fact quite possible that student effort might be more optimized by having more mind thrilling and spectacular projects that most likely will not be initialized by the industry. The enthusiasm for an inspiring task seems to be the key element in student performance.

The technical complexity of the project is always a key point. It should be high enough to constitute a challenge but reasonable enough to let the group find, navigate, sift and choose between competing solutions. The task must be chosen with respect to the team size, composition, budget, level of pre-knowledge and other recourses. The task should preferably be changed every year since this lets the group take on the task with a minimum of preconceived notion of the task that vitalizes the conceptual phase. A risk when repeating the course is the yearly increase of task complexity due to the fact that the teachers get familiar with the format that unconsciously seem to lead to escalation of the technical goals.

Regardless of the size of the groups, the length of the project and complexity of the task, a structured way to administer the project is vital. The use of a project model is thus mandatory as a way to introduce suitable common rules, definitions, templates, communication flow and timing of events. A quite successful detail of the implementation of the project model is to let the group actively participate in planning of the various delivery dates, such as the design review dates and the phase transition dates to comply in best possible way with the student's academic agenda. This significant influence gives the students a sense of involvement that has proven to be appreciated.

Sizing of the project groups is interesting where the optimal choice differs depending on the course objectives and various other constraints. Experience showed that in groups of size of 10-20 students the dynamics, needs and challenges become drastically changed compared with a group of say 3-5 students. As example, the true need for efficient information flow becomes evident in a larger group. The possibility appears for project members to selectively specialize within the project on skills ranging from e.g. solid mechanics, through fluid dynamics to project management.

2.4. Assessment

When discussing the topic amongst teachers one typically meets either the opinion that grading cannot be done in courses like this or the opinion that grading is self evident. One might debate whether grades in a DB-course act as stimulus for good achievements or just as a source for anxiety. For several reasons, also discussed in more detail in [7], the teachers at KTH have practiced both formative and summative assessment along with grading and are convinced that grading actually serves its purpose to enhance learning.

Each student continuously keeps track of time spent on the project, what the time is spent on and the outcome (evidence) of the effort. This, along with references to reports etc. will form the basis for their personal reflecting journal or portfolios. Apart from the effects of contemplation the self-assessment and writing of narrative gives a highlighted list of achievements, i.e. an index to the student's portfolio. The final part of the assessment scheme is that the involved teachers also go through the grading process and, if necessary, are prepared to act on e.g. conceivable unjust settlements between students.

The teacher's role has decreased in the actual grading part of the assessment procedure. It has been observed that e.g. small project groups tend to result in higher individual grades and that a technical success of the project is likely influencing the individual grades too much. It is thus a task for the teacher to guide the process to in the end reflect the learning and achievements of the individuals with respect to the course curriculum.

An improvement of the system is currently being developed and implemented. The change is aiming at increased teacher influence on the assessment. Prior to the peer modification the teaching staff will evaluate the project against a list of clearly defined attributes, such as a thinned out version of the CDIO syllabus [10]. This evaluation will result in a set of grades for the project as a whole and not on individual basis. During the following peer assessment the average of the individual grades from each student must comply with the project grades.

Whereas the individual success in a traditional course typically is measured by the results in a test the most appropriate gauge for measuring success in a DB course is far from obvious. One might spontaneously be mislead to confuse various degrees of technical achievements done by the project group with individual performance. Apart from the aspects of correlation between technical success and grading the appreciation and boost of self-confidence that the project member experience after meeting the technical goals are worth striving for.

2.5. Challenges

There are some challenges in mastering project based DB-courses that are worth focusing on some extra. The open format is fairly new to many participants that instantaneously lead to the question of responsibilities, incentives and control. The individual responsibility for the project is known to be one of the more challenging issues in the student run project. The potential misuse of trust from one project member can lead to severe consequences. The reoccurring missing of deadlines is one of the more obvious and unambiguous warning signals. Up to the deadline a project member can easily get away with not distinguishing between "working on a task" and "solving a task". Hence, a free format supported by fairly short deadlines with good follow-up is recommended.

It is important to advise both the individual student as well as the group in an atmosphere of confidence rather than to retain the usual distance and strict hierarchy between the student and the teacher. Associated with this new role of the teacher another comprehensive choice is to be made. As a teacher with experience from both project work and technical knowledge it is quite easy to become involved in the actual solving of technical problems. The choice to be made by the teacher is whether the technical solutions should reflect the knowledge and skills of the project group or the level of the teaching staff. The feedback from occasions where teachers interfere with technical solutions usually comes promptly as students tend to cut themselves off from solutions that are not originally theirs. The conclusion to this point is that less technical interference from the teacher lead to higher sense of project ownership from the project members.

3. FESB capabilities for implementation of project based learning

The authors have compared capabilities on both institutions, the KTH and the FESB, for construction of project based (design-build) courses organized and conducted in accordance to the CDIO-principles. It was found that similar preconditions exist at Department of Aeronautical and Vehicle Engineering at KTH and at Department of Mechanical Engineering and Naval Architecture at FESB, regarding number of enrolled students who could attend CDIO based courses, number of teaching staff and available spaces for student work. Differences also exist and can be summarized in following categories:

1. number and topics of courses on NA and ME studies on both undergraduate and graduate levels,
2. contacts and projects with industry,
3. laboratory and workshop facilities and equipment and number and competences of professional lab-staff,
4. teachers' pedagogic education.

Number and particularly topics of courses on studies at the KTH and FESB are significantly different. The courses at FESB are still, after the implementation of the Bologna system that was introduced in 2003, too theoretical and lectured in a traditional manner. Studies itself are too narrowly oriented - there are only 3 different master level profiles (specializations) at FESB while the KTH offers more than 15. On the undergraduate level there are no courses that cover fundamental engineering knowledge like electrical and electronic engineering, control systems, sound and vibrations, etc. On graduate studies there are no courses that cover modern materials and technologies, like composite materials and technologies or even more advanced nano-materials and technologies. Courses with, today fundamental, engineering analysis knowledge are missing at FESB - there is no even course about FE analysis, which today is one of the basic engineering analysis tools. Additionally, there is only one 'specialization' in naval architecture, which has become too general and due to limited number of courses per semester introduced with Bologna system, too crippled, i.e. it covers some topics in too much details, while other are not even mentioned. In contrast to that at the KTH there is 5 profiles offered to NA graduate students (Lightweight Structures, Fluid Mechanics, Sound&Vibration, Management and Sustainable Development) with the same number of teaching staff at both departments. Additionally, all the profiles (courses) at the KTH are organized according to CDIO-principles.

The reason for such a pathetic situation with study programmes at FESB is that some significant errors were made during transformation from the old 4-year education system to the 3+2 year Bologna system, which happened after the adoption of the Bologna declaration. This is particularly pronounced on the undergraduate (first) levels at mechanical engineering and naval architecture studies. When change was announced that there should be 'only' 3 years for the first level, instead of 4 years, problem aroused which courses to keep at undergraduate level and which ones to transfer to graduate level. The problem was 'solved' by keeping most of the courses at undergraduate level but only with reduced number of weekly hours per course. In our experience this was and still is the major cause for high drop out of students. This 'solution' has too many courses, all of them being lectured in a same way as before thus making it very hard for students to pass all the exams. This 'mess' has also caused a reduced number of specializations at graduate level since some fundamental engineering knowledge, necessary for certain specializations, has been missing.

The project based learning in its core requires broader fundamental engineering knowledge (often interdisciplinary) and this means that study programmes at FESB should have to pass through significant changes. Not only changes in fundamentals are necessary but also programmes need to modernize (i.e. cover modern and advanced engineering topics) and they need to become flexibly organized in order easily adapt in case of future changes (i.e. simple and fast introduction of new specializations). The FESB is now trying to improve the situation by introduction of study programmes according to the ASIIN and SEFI standards.

Contacts and projects with industry are very important part of the KTH functionality as source of funds and project ideas. It is also a source of attractiveness for students, since they realize that what is being done at the university is not purely academic and scientific, but also connected with a real world. The main source of funds for FESB (and all other universities in Croatia) is still the government. Thus, the vast majority of the projects funded by Ministry of Science and Education are concerned only with pure scientific output (number of published papers) and there is nothing in those projects related with either students or industry. Regarding contacts with industry there has not been healthy relationship between universities and companies. If there were any contacts it was usually in a way that some necessary work has been performed at the university that could not be done in the companies, such as testing and measurements. It was often cheaper to ask such services from faculties than from professionals on the market - there was rarely some systematic and prudential cooperation in contrast to form of cooperation that the KTH has with the industry. However, situation regarding contacts with industry is now improving at FESB, but at a slow pace. New contracts and agreements between some companies and the FESB now include projects that involve students. The students also, and not only university staff as it was the case until now, will be included in projects and they will have both university and industry resources at disposal.

Although some differences exist in laboratory facilities and equipment, with KTH being in considerably better position, these should not be considered as a major obstacle for implementation of project based learning methods at FESB. Department of Mechanical Engineering and Naval Architecture has on disposal 4 classrooms equipped with computers, ranging in size from 6 to 20 computers, which is more than enough for our current needs, i.e. number of students enrolled. The software on computers ranges from basic office programs to professional software systems like CATIA. Naval Architecture division has one lab that is currently unequipped – due to crisis and recession the funds from the government have been cut down. The intention is to equip this lab with necessary tools and machines for building and testing models made of composite materials. Until then, agreements with some companies will allow for students to use industry facilities for building and testing models.

There is also a number of specialized laboratories at FESB (mechanics, vibrations, engineering design, metallic materials and technologies, fluid mechanics, thermodynamics, etc.) that could be put to a good use regarding implementation of the project based learning methods. However, the quality of professional lab staff is very questionable at FESB. There is no clear standard about which qualifications a certain lab professional should have. It led to employment of inappropriately qualified (or unqualified) persons.

It can be added that naval architecture studies in particular are missing the indoor testing basin (or a pool) since faculty does not have one and there are no companies near Split that also have one. Someone may notice that projects in naval architecture may always use the sea as a 'testing basin', which of course is inadequate.

In authors opinion the fourth point in the list of differences between the KTH and FESB (teachers' pedagogic education), is the most important for the successful implementation of the project based learning methods and it will be the most difficult to deal with. At FESB nothing has ever been invested in teachers' perception and knowledge about engineering education. In contrast to FESB at KTH all teachers have formal pedagogic education and documented experience from teaching as well as from course and program development and management. Also, at KTH teacher redundancy and sustainability is secured by sharing the responsibility for each of the program core courses between several teachers. Lack of formal pedagogic education of teachers is probably the main reason why the courses at FESB remained unattractive (or 'boring') for students. Traditional role of a teacher as a 'teller' has become a firm habit while there is no one to say whether someone is a good 'teller' or not. It has been up to the teachers to improve themselves, i.e. their teaching skills in a manner they thought were the best. Some of them have never change, no matter what changes had been introduced in study programmes, and it seems that they never will unless compelled to. This is something that cannot be done at the department level and there is a question whether it could be done at the faculty or even university level. Such a significant change in behavior and habits of teachers probably will have to be forced by the Ministry of science itself. There are however some signs of changes: on one hand some teacher have voluntarily started to improve their teaching methods and on the other the teachers' evaluation system has been introduced. The students now have the chance to evaluate teachers' work and these evaluations have slowly started to make some influence on teaching methods.

Additional problem, and very serious one, with teachers at FESB is that their willingness to learn and introduce new topics is in some cases very low. Some of the teachers have established their positions within faculty that they are not willing to change. For this reason it is vital that FESB has more contacts with universities abroad (since most of the Croatian universities 'suffer' from the same teachers' symptoms) in order to enlighten teachers and provoke them to make some changes. Regarding enlightenment it is also important to send teachers, researchers and students to spend some time at universities abroad. Hopefully, when enough teachers gain insight in teaching and learning standards at foreign universities it should be easier to introduce changes regarding teachers' pedagogic education.

4. Outcomes of CDIO based courses at KTH

The following figures present examples of novel crafts Conceived, Designed, Implemented and Operated by students in the courses at KTH. These projects provide important marketing for KTH through frequent attention in TV and other media, fairs, and currently on kthpainsidan.se.

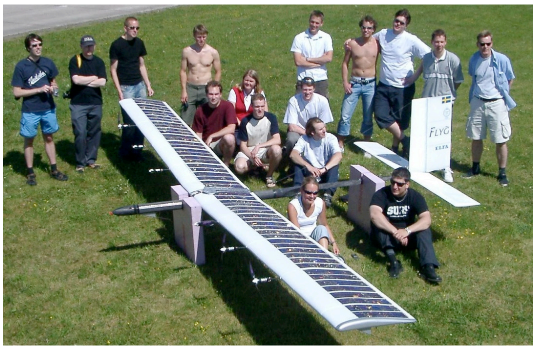

Fig. 1 The student engineered solar powered aircraft (2001) *after* successful test flight

Slika 1. Studentski projekt zrakoplova na
solarni pogon (2001) nakon uspješnog testnog leta

Fig. 2 The human powered water bike (2003)

Slika 2. Vodocikl na ljudski pogon (2003)

Fig. 3 Infernus, the high-speed craft with underwater capabilities (2004)

Slika 3. Infernus, brzo plovilo sa podvodnim mogućnostima (2004)

Fig. 4 Amphibious vehicle

Slika 4. Amfibijsko vozilo

Fig. 5 The environmentally sustainable commuter boat Kaimaran (2008)

Slika 5. Kaimaran, ekološki prihvatljivo plovilo (2008)

Fig. 6 Evolo, the electric water-toy (2009)

Slika 6. Evolo, električno plovilo za zabavu i rekreaciju (2009)

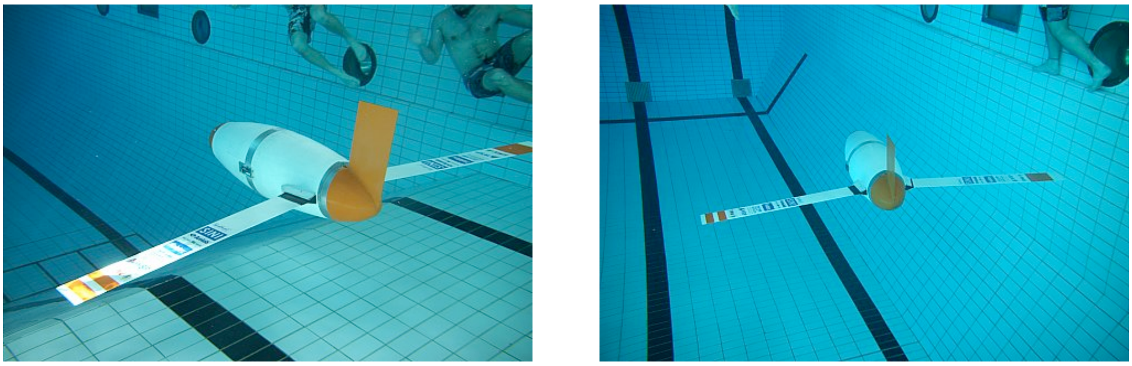

Fig. 7 The underwater glider and environmental probing platform Balder (2010)

Slika 7. Podvodna jedrilica i plaftorma za ispitivanje okoliša - Balder (2010)

5. Conclusion

Negative feedbacks from students of mechanical engineering and naval architecture at FESB about 'boring' courses and studies, combined with their common attitude that 'what we learn at faculty has nothing to do with the real world' has provoked activities of teachers to start improving teaching and learning methods. In the engineering education the project based learning has a natural place since the student when graduated likely will work in projects from day one in industry. Project-based learning emphasizes learning activities that are student-centered. This approach is structured differently than traditional, teacher-led classroom activities where teacher is 'telling' and students are 'doing'. Teacher has a different role here - he/she works as a coach of knowledge development and social skills rather than knowledge-holder and disseminator. Students become active in problem solving, decision making process and they collaborate or cooperate forming groups, organize their activities, conduct research, solve problems, synthesize information, organize time and resources and reflect on their learning.

Presented experience of the application of project based learning in engineering studies at KTH has showed great benefits of the approach for both students and teachers. Analysis of teaching and learning conditions at the KTH and comparison with the FESB capabilities pointed out some crucial differences. It was concluded that most of them could be reduced relatively easily, by organizing study programmes according to some international standards and by improving contacts with industry. However, one major obstacle remains to be dealt with - necessary improvement of pedagogic skills of teaching and academic staff at FESB.

Authors are also familiar with situation at other Croatian engineering faculties, particularly mechanical engineering and naval architecture, and we can point out that the same, or very similar, problems can be found there.

REFERENCES

[1] ASIIN e.V.: Requirements and Procedural Principles for the Accreditation and Reaccreditation of Bachelor's and Master's Degree Programmes in Engineering, Architecture, Informatics, Natural Sciences and Mathematics, 2008.

[2] SEFI Reference Documents, http://www.sefi.be.

[3] P. Johnson (1999), Problem-Based, Cooperative Learning in the Engineering Classroom, Journal of Professional Issues in Engineering Education and Practice, 125(1), 8-11.

[4] J.W. Thomas (2000), A review of research on project-based learning. The Autodesk Foundation.

[5] BEST Educational Committee: Active learning in Engineering Education, BEST Symposium on Education, Porto, 1st May – 6th May 2006.

[6] K. Žiha, Creativity and Engineering Education. Experience and Sustainability of International Curriculum Development in Naval Architecture, University of Zagreb, 2009.

[7] J. Biggs, Teaching for quality learning at university, 2nd edition , St Edmoundsbury Press Ltd, Suffolk, ISBN 0 335 21168 2, England, 2003.

[8] E.F. Crawley, The CDIO Syllabus: A Statement of Goals for Undergraduate Engineering Education, MIT CDIO Report #1, Dept of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, MA, USA, 2001.

[9] K. Edström , K. El Gaidi, S. Hallström, J. Kuttenkeuler, Integrated assessment of disciplinary, personal and interpersonal skills- iterative development based on student responses, 13th Improving Student Learning, London 5-7 September, 2005.

[10] J. Malmqvist, P.W. Young, S. Hallström, T. Svensson, Lessons Learned from Design-Test-Build-Based Project Courses, International Design Conference – Design 2004, Dubrovnik, May 2004.